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Climate consequences of large-scale land-use changes as climate engineering tools

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Terrestrial carbon sinks are much-discussed as climate engineering methods both in politics and science. The debate focuses mostly on their potential for carbon sequestration and fossil-fuel substitution, whereas other effects such as changes in heat and water fluxes are often ignored. We assess potentials and side-effects of two different land-use types suggested as climate engineering tools, forest and herbaceous biomass plantations.
We integrate herbaceous biomass plantations as new plant functional types into the land component (JSBACH) of the Max-Planck-Institute Earth System Model (MPI-ESM). Herbaceous biomass plantations alter surface albedo, carbon and water cycles compared to forests. We adapted the JSBACH carbon cycle (assimilation and respiration) to reflect a highly productive biomass grass and the phenology to account for harvests just before the beginning of the growing season. The harvested material is transferred to a separate pool that can be adapted to reflect different biomass utilization pathways. Where possible, the model was validated using yield measurements and water-use efficiency calculations available from literature data.
We compare the potentials and side-effects of afforestation and herbaceous biomass plantations in a plausible global scenario: under the representative concentration pathway (RCP) 4.5, large areas of agricultural lands are projected to be abandoned as food production intensifies on the most productive soils. We intend to model the climatic consequences of using these abandoned croplands for afforestation or biomass plantations, under an RCP 8.5 forcing (high CO_2 emissions). We emphasize differences between biogeochemical and biogeophysical effects of land-use on climate and how these factors interact on the local and global scale. Apart from direct climatic effects (energy, water, and carbon fluxes), we attempt to consistently account for fossil-fuel substitution effects of biomass plantations in a coupled model.
This study comprises the fist part of a larger project analyzing four different land-use types: unmanaged forest, managed forest, woody biomass plantations and herbaceous biomass plantations. Our study is part of the interdisciplinary program ‘Climate Engineering: Risks, Challenges and Opportunities?’ which allows for a consistent comparison of land-based climate engineering to other methods such as solar radiation management or ocean alkalinization.